## ATMOSPHERIC EFFECTS IN ASTRONOMICAL OBSERVATIONS.

It is well known that the study of the twinkling or scintillation of the stars, as also the study of the so-called shadow bands accompanying total solar eclipses, has given us the means of measuring the sizes and motions of the little masses of warm and cold air of which the atmosphere is a mixture; so also the study of dust whirls and of the alternations of temperature in the foehn wind has given us some idea of the mixture of the larger masses of ascending warm and descending cool air. The delicate photographic work of Prof. Percival Lowell and his assistants, of the Flagstaff Observatory, has brought out another optical effect in the atmosphere, due to the presence of quite regular alternations of refraction, which may be spoken of as optical waves. These irregularities may be produced either by alternations of pressure, as in sound waves, or by alternations of temperature and moisture; or again they may be conceived of as gravity waves on an otherwise horizontal surface, separating layers of air of different density. Every astronomical observatory is troubled by the irregularities of refraction in the atmosphere above it. In a perfectly still, clear night, when cool air gathers round the observatory, there is some upper boundary surface near by along which air is flowing, perhaps gently, or, it may be, very rapidly, and in this boundary region waves and curls like breakers and mixtures are continually occurring. A beam of light passing through such a mixture down to the telescope and examined with a high magnifying power is seen to be in continual oscillation about an average position, and the eye recognizes this motion as such; but if a photographic plate be substituted for the eye, the varying positions of the moving image, being superposed upon each other, are all recorded permanently, so that the sensitive plate shows a large blurred image instead of a definite point; therefore we measure from the center of this image as representing approximately the location of the sharp point that we would have preferred to photograph. If we attempt to photograph a delicate line in the spectrum of any celestial body, we find that it also is blurred, or, as we say, broadened, rather than narrow and sharp. Similarly the narrow bands or markings on the planet Mars, called canals, which have been the special study of Professor Lowell, may appear blurred and indefinite when photographed, although in favorable momentary glances the eye may recognize the fact that they are very narrow and sharp. But illusions occur even in these momentary glances, since we are looking through an atmosphere composed of something similar to prisms or lenses of warm and cold air, which may appreciably distort the truth. In other words, we are observing and photographing images due to diffraction, and it is only by studying the laws of diffraction that the astronomer learns to interpret what he sees and deduces the true characteristics of the celestial bodies, while the meteorologist deduces the nature of our atmospheric peculiarities.

These *diffraction phenomena* have been studied both experimentally and theoretically. One of the finest examples of experimental work is the famous and rather rare volume by Schwerd, on "beugung," or diffraction phenomena in telescopes. A more recent experimental and theoretical work is that by Hermann Struve, with especial application to the semicircular objective of the heliometer. The study of the diffraction phenomena in microscopy, by the late Professor Ernst Abbe, of Jena, led to all his famous improvements in optical instruments. American students who are familiar with the series of works published by Prof. W. H. C. Bartlett, of West Point, will have acquired a good ground work for the prosecution of studies in diffraction, or the interference of waves of all kinds. But most complete theoretical and historical expositions of the subject will be found in a volume published in Cambridge, Eng., in 1904, viz, "The Analytical Theory of Light," by James Walker, Demonstrator of Physics in the Clarendon Laboratory, Oxford, and again in the more recent "Physical Optics" of Prof. R. W. Wood, New York, 1905. Here we find the general formula for the diffraction patterns produced by apertures of any special form, and by light of any given wave-length or complexity. In order to resolve the markings on a minute microscopic object, or separate the close components of a double star, or perceive the delicate markings on a planetary surface, without being misled by diffraction phenomena, certain instrumental conditions must be fulfilled; such, for instance, as that mentioned on page 126 of Walker's treatise, namely that "the angular interval between the lines or markings on the object must exceed the angle subtended by the wave-length of light at a distance equal to the diameter of the circular aperture," namely the aperture of the object glass, if a telescope or microscope be used. The same law is given at page 190 of Wood's "Physical Optics."



On page 265, Mr. Walker demonstrates that when a telescope is focussed on a narrow line of monochromatic light [analogous to the canals of Mars] and the object glass is limited to a slit parallel to this line [analogous to the atmospheric lenses that Professor Lowell calls waves], the geometrical image of the line is bordered by a system of diffraction fringes; on covering one-half of the slit with a retarding plate, the bands of an odd order are shifted toward the side of the retarded stream [analogous to the effect of a rapid succession of atmospheric waves and also analogous to the effect produced by the movable spider-line of the micrometer when one attempts accurate measurement].

In this study of diffraction phenomena, Professor Lowell has made an important advance, as explained in an article by him in the Proceedings of the Royal Society, published February 8, 1906, page 132. By many experiments and measurements he found:

> The so-called air waves were detrimental in two ways, depending upon their size relative to the diameter of the object glass. They are made up of trains of waves, of condensation and rarefaction, and if the distance from crest to hollow be equal to the diameter of the object glass the train will produce a series of bodily oscillations of the whole image in the field of view. If, however, the wave-length be shorter than this, partitive motion occurs, while the bodily motion is reduced, the result being that we have an apparently steady image, but a blurring and finally a complete obliteration of the delicate detail. * * * The image often appears to be perfectly shown, and yet discloses either no fine detail or else shows such only in a blurred and indefinite condition. This is the reason that the canals are often reported to be streaks, whereas under better atmospheric conditions, namely when the relatively small waves are absent, they appear as they really are, very narrow dark lines. The other aspect is produced by the blurring tremor of the air waves, the real image of the canal being thus spread out, and consequently diffused. The larger the glass the more likely is this state of confused illusion to occur, a knowledge of which suggested to us the diaphragming down of the 24-inch objective, with a result which was truly surprising. It was found very rare that the definition was not improved by this artifice. The same device was next applied to photography, and the camera entirely corroborated the evidence of the eye.

In securing the photographs published by Lowell with this article, the objective was diaphragmed down to suit the particular atmospheric wave currents traveling at the moment in front of the telescope. Side by side with Lowell's photographic prints are reproductions of his hand drawings, made independently of the photographs, but at the same time.

The sizes and movements of these atmospheric waves will form an interesting subject for the study of meteorologists. In general, however, we can at present see no way by which to determine the distances of the atmospheric irregularities from the observer, their altitude above him, or their special nature, whether due to temperature, pressure, or wave-motion between boundary surfaces. In any case, however, they give rise to phenomena of diffraction, or the interference of nearly parallel rays of light.

It may also be questioned whether some of the color phenomena seen on the disks of the planets, especially Jupiter and Saturn, may not also be diffraction phenomena originating in their own moist atmospheres, just as halos and other colored beams originate in the earth's atmosphere. The changes of tint on the surfaces of the clouds of Jupiter and Saturn occur at certain angular distances from the sun and earth, such as to make this suggestion worthy of special study. The elaborate works of Mascart, Pernter, and others on this subject must be studied by those who would go into precise details.—*C. A.*

## THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS.

The report of the Eighth International Geographic Congress, held in the United States in 1904, has recently been published by the Government as Document No. 460, House of Representatives, 58th Congress, 3d session, Washington, 1905. In its wealth of geographic papers we find the following articles bearing directly upon meteorology:

Pages 246-265. Meteorological summary for Agaña, island of Guam, for the year 1902. By Dr. Cleveland Abbe, jr., of the U. S. Geological Survey.

Pages 266-271. A climatological dictionary for the United States. By Prof. A. J. Henry.

Pages 272-276. Scientific work of Mount Weather Meteorological Observatory. By Prof. F. H. Bigelow.

Pages 277-293. Suggestions concerning a more rational treatment of climatology. By Prof. R. DeC. Ward.

Pages 294-307. The Canadian climate. By Prof. R. F. Stupart.

Pages 308-321. The climate of Kimberley. By J. R. Sutton.

Page 322. A project for the exploration of the atmosphere over the tropical oceans. By A. Lawrence Rotch.

Pages 323-327. Antarctic meteorology and international cooperation in polar work. By Henryk Arctowski.

Pages 328-339. De la prédominance des tourbillons, en sens inverse des aiguilles d'une montre, dans les cours d'eau de l'Europe centrale et occidentale. By Jean Brunhes.

Pages 340-342. Rainfall with altitude in England and Wales. By William Marriott.

Pages 343-347. Climatology of the lowlands and watershed terraces of Natal. By Frederick W. D'Evelyn.

Pages 348-351. Aerostation associated with the study of geography. By E. V. Boulanger.

Pages 352-379. Climate of Pamplemousses, in the island of Mauritius. By T. F. Claxton.

Pages 380-385. Climate of Ts'aidam, in eastern Tibet. By A. Kaminski.

Pages 386-392. Meteorology of Western Australia. By W. Ernest Cooke.

Pages 393-396. On the unsymmetrical distribution of rainfall about the path of a barometric depression crossing the British Isles. By Hugh Robert Mill.

Pages 397-406. Evidences of land near the North Pole. R. A. Harris.

Pages 408-424. (In German.) Winds and ocean currents. By E. Witte.

Pages 465-467. (In German.) Vertical motions of the earth observed by the trifilar gravimeter. By Dr. A. Schmidt.

Pages 468-477. (In German.) The foundation, organization, and problems of the International Seismological Association. By Dr. G. Gerland.

Pages 535-540. The form of the geoid, as determined by measurements in the United States. By John F. Hayford.

Pages 664-670. Climate and cult. By J. Walter Fewkes.

Pages 711-714. Color in the north and south polar regions. By Frank Wilbert Stokes.

Pages 737-740. The scientific results of the Russian expedition to Kham. By Capt. P. Kozloff.

Each of the items in the above list is worthy of a fuller abstract than we can give it. The volume can be easily obtained by application to any member of Congress, and should be in the hands of every teacher and special student.—*C. A.*

## THE LEGITIMATE LINE OF DUTY.

During the month of March the Weather Bureau and other branches of the Department of Agriculture received from correspondents in several different States requests for authoritative replies to various questions which turned out to be identically the same, and many of which did not relate to the work of the Department of Agriculture. In some cases the questions came from teachers or scholars, in others from the cooperative observers of the Weather Bureau. Our first temptation to answer these questions, as a kindness to our correspondents, was quickly modified by the consideration that as these all had a common origin they very probably related to some competitive or other civil service examination, with which it was improper for a Government bureau to interfere. Therefore in some cases the questions were not answered.

On further inquiry, however, the Editor discovered that these 27 questions emanated from a very enterprising manufacturer of pianos, or his business agent, who took this method of advertising his pianos. It is not often that the United States Government is made a party to any such advertising scheme, and it is earnestly to be hoped that in future struggles for a prize no observer or correspondent of the Weather Bureau will again attempt to enlist its kind offices.

Several cases have come to the Editor's knowledge during the past twenty years in which Government officials have been requested to act as umpires or give authoritative decisions as to points under discussion. The Government was not established for any such purpose as this, and such correspondence will always remain unanswered as being outside our legitimate line of duty.—*C. A.*

## THE TORNADO AT MERIDIAN, MISS., MARCH 2, 1906.

By LEE A. DENSON, Observer, Weather Bureau. [Extract from Form 1014 A.]

The tornado that visited Meridian on the evening of March 2 was the most destructive local disturbance ever observed in eastern Mississippi. Twenty-three people were killed, and it is estimated that the loss of property damaged or destroyed is about $400,000.

The sky had been cloudy all day and occasional light showers occurred, the temperature being above normal, with maximum, 69° F., shortly after noon. A fresh breeze from the south and southeast prevailed, in connection with a large barometric depression that was moving eastward across the central portion of the country, but notwithstanding the breeze the atmosphere became oppressive and toward evening a heavy bank of dark strato-cumulus clouds was observed in the southwest, from the front of which occasional small streaks of lightning issued. Distant rumbling thunder was heard at 5:40 p. m. At 6 p. m. the clouds had assumed a very threatening aspect and rain began to fall at 6:05. There were frequent flashes of sheet lightning. About 6:20 p. m. a sound resembling the noise made by a fast moving freight train came from the southwest. The sound became louder and louder, attaining a terrific roar for a minute as the disturbance passed. All was quiet again at 6:30 p. m. The center of the storm passed 250 yards south of the local office of the Weather Bureau, moving a little north of east, at 6:26 to 6:27 p. m. The barograph pen dipped sixteen hundredths of an inch and recovered immediately (see fig. 1); the temperature fell only 2° F. and recovered 1° F. within 10 minutes. At 6:15 p. m. the velocity of the wind was only 9 miles from the southeast; at 6:20 it was 16 east, backing to northeast at 6:22 and returning to east at 6:23 and to southwest a minute later when there was a marked increase in the velocity, the direction being south at 6:25, east at 6:26, and west at 6:27 p. m. The greatest velocity recorded was 64 miles from the east, as the storm passed. Immediately afterward the rate diminished to 36 from the west and 5 minutes later it was 12 miles from the southwest. This record clearly shows the inward rush of air toward the center of the storm.

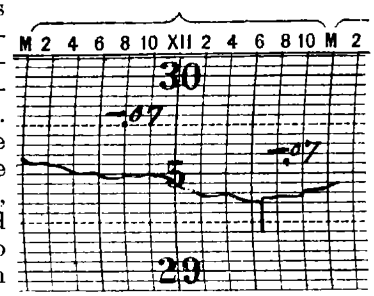

FIG. 1.—Barogram at the office of the U. S. Weather Bureau, Meridian, Miss., March 2, 1906.